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SOLAR SIMULATION WITH A RECTANGULAR BEAM

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ABSTRACT

An existing space simulation test facility was modified by enlarging the solar simulator. Because of restrictions imposed by existing equipment, the shape of the solar beam was altered from a circular to a rectangular cross section in order to adapt the test facility to test objects of increased size. This modification is described together with the results of prelimimary measurements.

INTRODUCTION

Since the beginning of satellite production in West Germany, approximately 25 years ago, IABG has been involved in the testing of space hardware. In 1983 a new, relatively large space simulation test facility became operational[1], a schematic diagram of which is shown in fig. 1; fig. 2 shows a photograph of the open chamber. The main characteristics of the facility are:

Test Volume Dimensions

- Between Lid and Shutter: 7.5 m
- Between Lid and Mirror: 12.0 m
- Diameter: approx. 6.2 m

Solar Beam

- Diameter: 3.6 m
- Intensity max.: 1.4 solar constants
- Parallel Beam with Collimation Angle: $\pm 2^{\circ}$

Shroud

- Temperature Range: <100 K to 400 K

Vacuum

- Pressure: $<10^{-5}$ mbar
- Oil free high vacuum pumps

Motion Simulator:

Two axes of rotation:

- Attitude axis: $\pm 200^{o}$
- Spin axis continuous rotation up to 10 rev. per minute

Max. Dimensions of Test Specimen

- Height: approx. 5.0 m
- Diameter: approx. 4.0 m
- Mass: approx. 2000 - 2500 kg

The facility has been used extensively for testing satellites and subsystems of national and international programmes. It has also been used for special deformation measurements by means of laser holography which were reported during the 13th Space Simulation Conference in 1984[2)].

MODIFICATION OF SOLAR SIMULATOR

With the increase of launcher capacities and a corresponding increase in satellite sizes we began to study the possibilities of enlarging the usable test volume of our facility. Since the dimensions of the chamber itself and of the shroud could not be altered, we focused our attention on the solar beam, which also represented the main limitation.

The solar simulator consists essentially of (see fig. 1)

- the lamp housing with up to 7 lamps of 25 kw each
- the integrator, an array of lenses
- the window as interface between the vacuum inside and the atmospheric pressure outside the chamber
- the collimation mirror inside the chamber, consisting of hexagonal segments

This arrangement, the lay-out of which was developed at IABG, yields a very good intensity distribution across the solar beam (± 3 %) with a collimation angle of $\pm 2^{\circ}$. The efficiency is better than 12 %. These values were obtained by means of extensive analysis and optimisation using mathematical models. For example, the collector mirrors were designed for a light source of finite length with a given intensity distribution.

Each of the integrator lenses distributes the light over the total beam area; therefore, switching or exchanging of lamps has hardly any effect on the intensity distribution in the target area.

A further advantage of this solar simulator design is its modular concept, which allows easy exchange of lamps, power supplies, etc.

Due to restraints imposed by the building and the chamber, it was not possible to simply increase the number of lamps and, correspondingly, the size of the collimation mirror in order to enlarge the solar beam. Instead, the following modifications were made after a number of calculations aimed at an optimised solution:

- o The integrator was replaced by a new one containing rectangular instead of circular lenses.
- o The collimation mirror was enlarged by a number of hexagonal segments.

These measures yielded a solar beam with a cross section of 3.05 m by 4.5 m, suitable for larger spacecraft than the 3.6 m dia beam, which covers square shaped spacecraft cross sections of up to 2.5 m side length.

The essential parameters of the two solar beams are listed in fig. 3. It can be seen that an increase of illuminated area of approximately 35 % is gained compared to a "loss" of maximum intensity of 7 %. This reduction was considered acceptable since 1.36 SC leaves a comfortable margin above the standard 1 SC. The gain is mainly achieved by the improved packing factor of the rectangular integrator (27 %), a geometrical effect as shown in fig 4. The area covered by the support structure of the lenses, which does not transmit any light, is larger for the circular lenses than for the rectangular ones.

Fig. 5 shows photographs of the new integrator which was designed and manufactured by C. Zeiss at Oberkochen, West Germany.

Preliminary measurements of the rectangular solar beam show that the intensity distribution is better than ± 3 % with the exception of the edges and very few points in the middle (Fig. 6). It should be noted that some mirror segments at the corners of the collimation mirror had not yet been installed at the time of these measurements; also the upper left corner of the beam is obstructed by the support structure of a radiometer.

These measurments were performed with an intensity of 0.83 kw/m^2; with full power of the 7 X 25 kw lamps a value of 1.8 kw/m^2 = 1.36 SC will be obtained.

CONCLUSION

By a relatively simple modification and with relatively low cost, the usable test volume of IABG's space simulation test facility was considerably enlarged (e.g. for ARIANE 3 spacecraft) and the range of potential customers increased. A further advantage is that changeover between the two solar beams can be achieved easily by exchanging the integrator only; no other modifications are required.

REFERENCES

1) H. E. Nuss und J. Reimann: The new space simulation and thermal vacuum facility WSA/TVA. Proc. of the International Symposium on Environmental and Thermal Systems for Space Vehicles, 1983, ESA SP-200

2) H. U. Frey: Distortion Measurement of Antennas under Space Simulation Conditions, 13th Space Simulation Conference, 1984, NASA Conference Publication 2340.

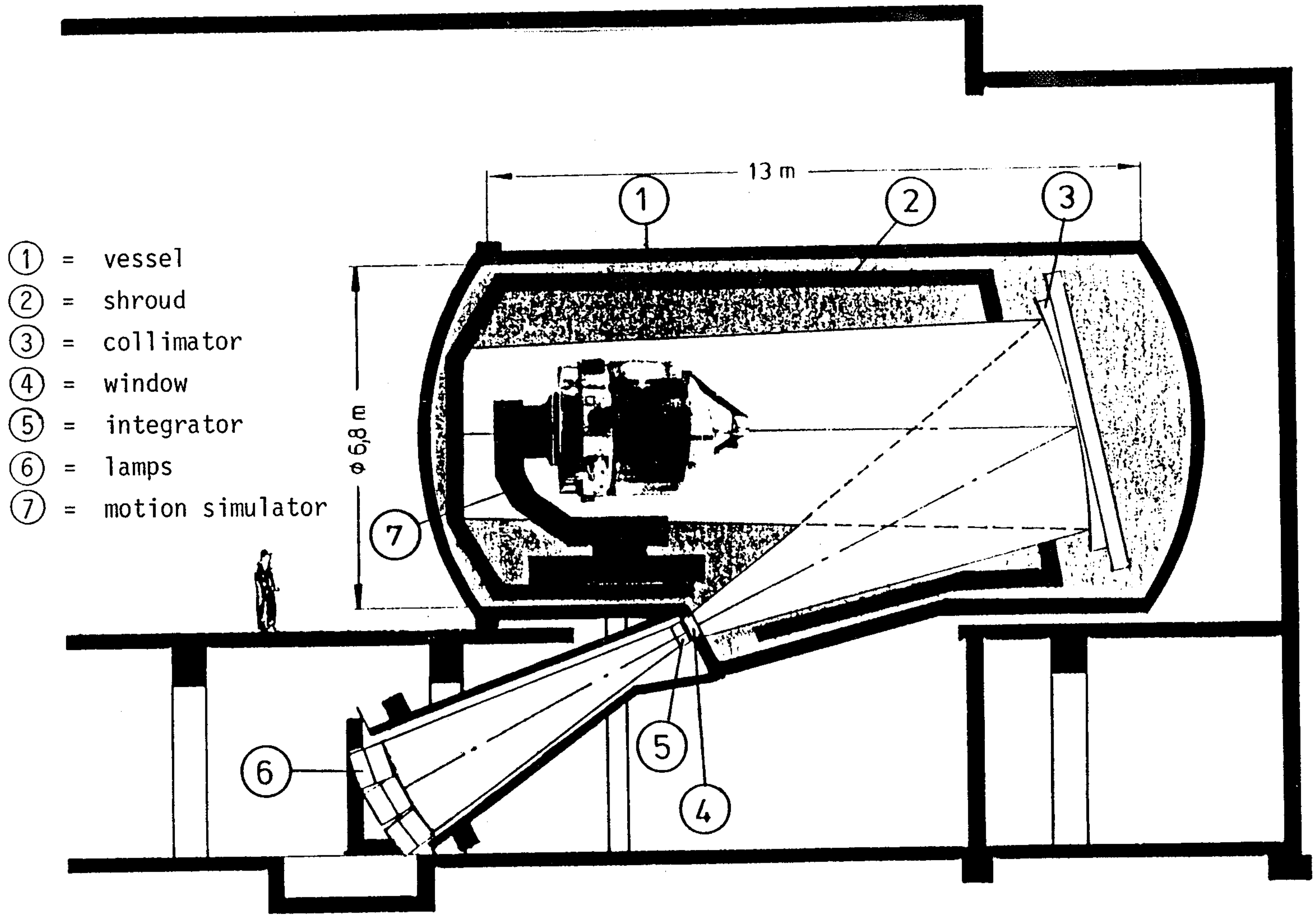

Fig. 1: Space Simulation Test Facility

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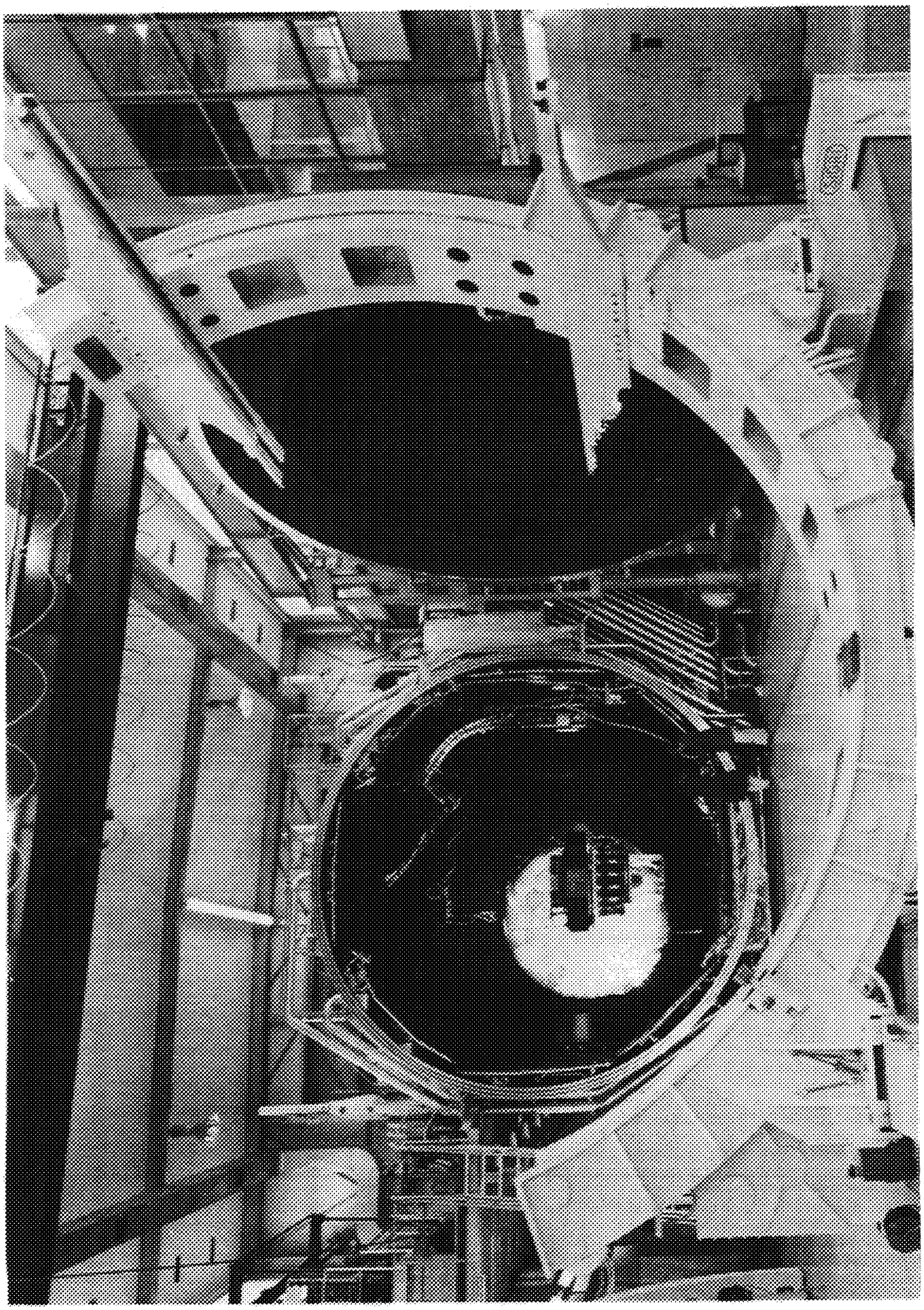

Fig. 2: View of the Space Simulation Test Facility

BEAM DIMENSIONS	DIA 3.6 M	3.05 M X 4.5 M
IRRADIATED AREA	10.2 M^2	13.7 M^2
NUMBER OF COLLIMATOR SEGMENTS	61	84
DIMENSIONS OF COLLIMATOR	4.2 M MIN. 5.0 M MAX.	4.2 M X 5.5 M
INTEGRATOR - PACKING FACTOR	2 X 31 CIRCULAR LENSES 0.71	2 X 65 RECTANGULAR LENSES 0.9
MAXIMUM SOLAR INTENSITY IN TEST PLANE	1.44 SC	1.36 SC

Fig. 3: Parameters of Solar Beams

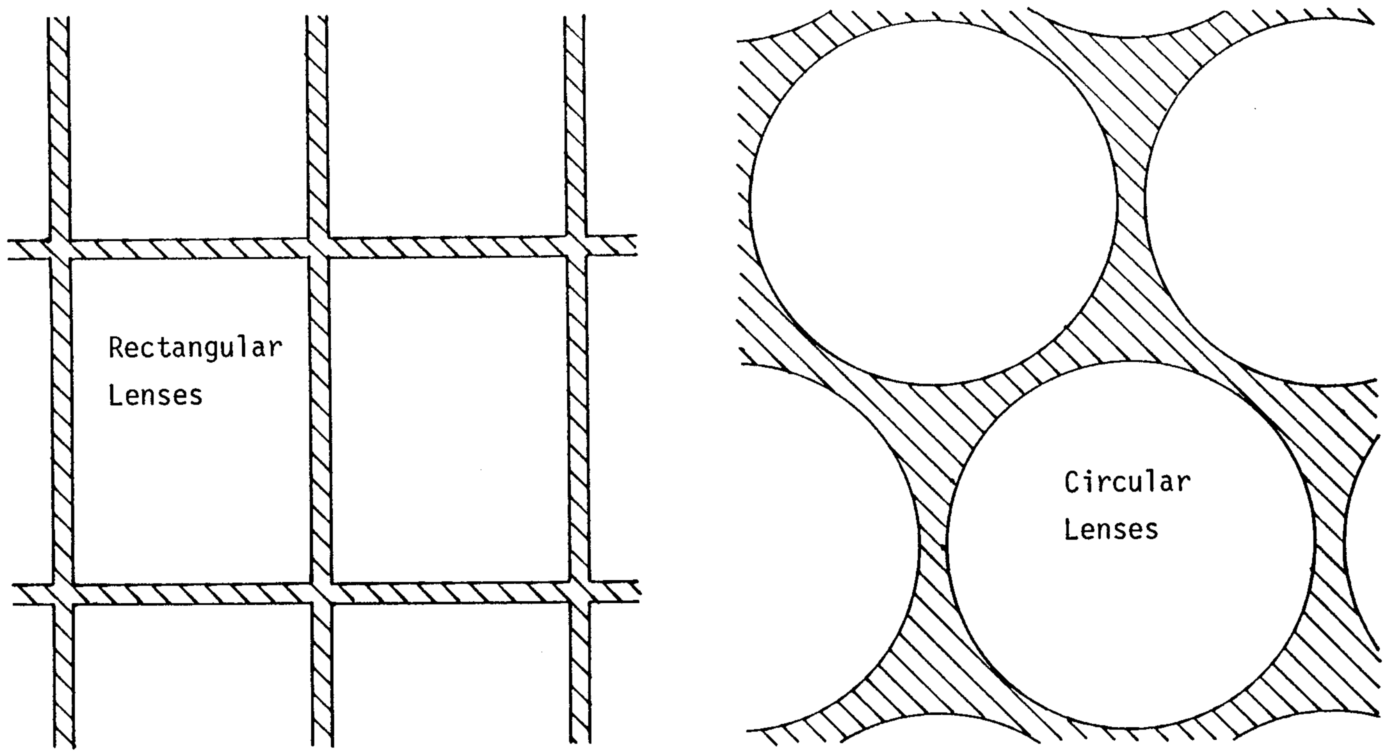

Fig. 4: Packing Factor of Integrator

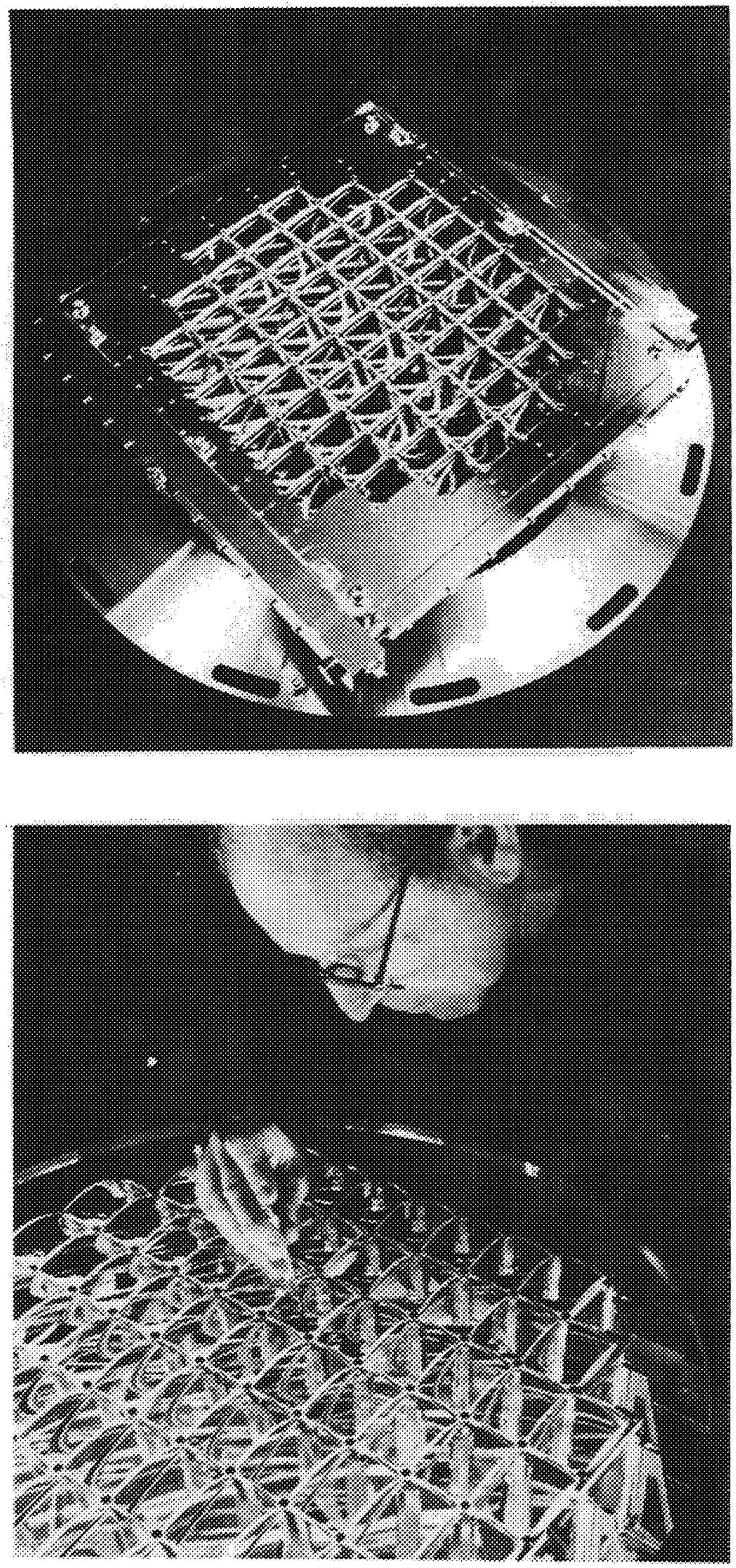

Fig. 5: Rectangular Integrator

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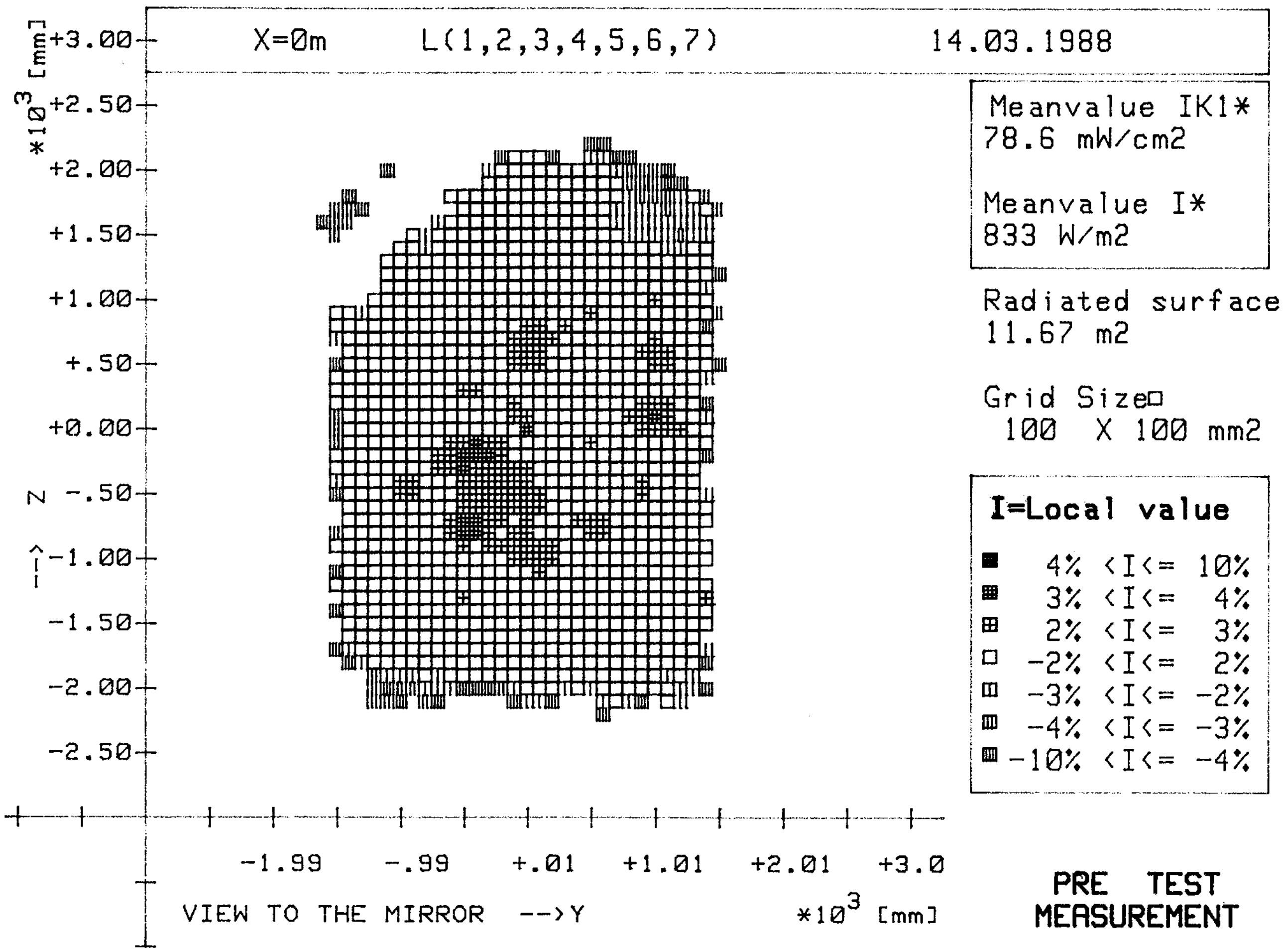

Fig. 6: Intensity Distribution - Rectangular Beam